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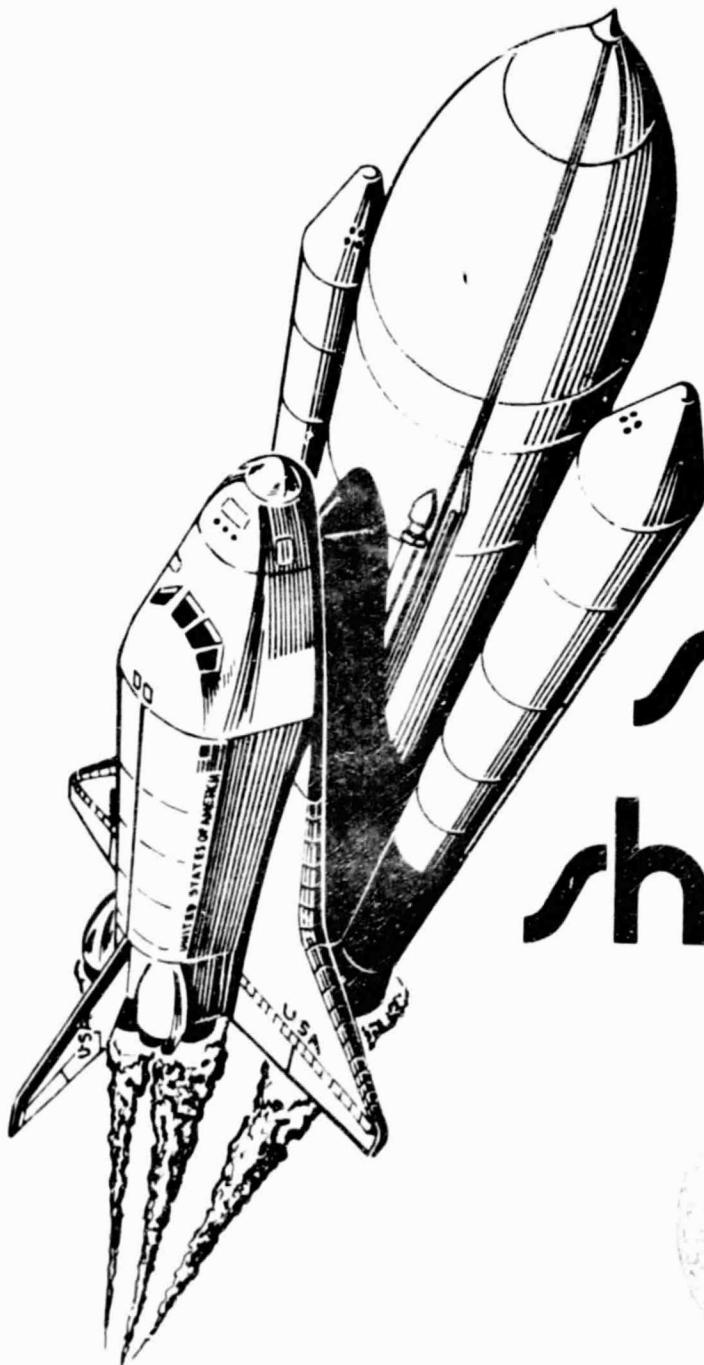
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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

FACT SHEET



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shuttle



Public Affairs Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

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Phone: 453-0034, 453-0035

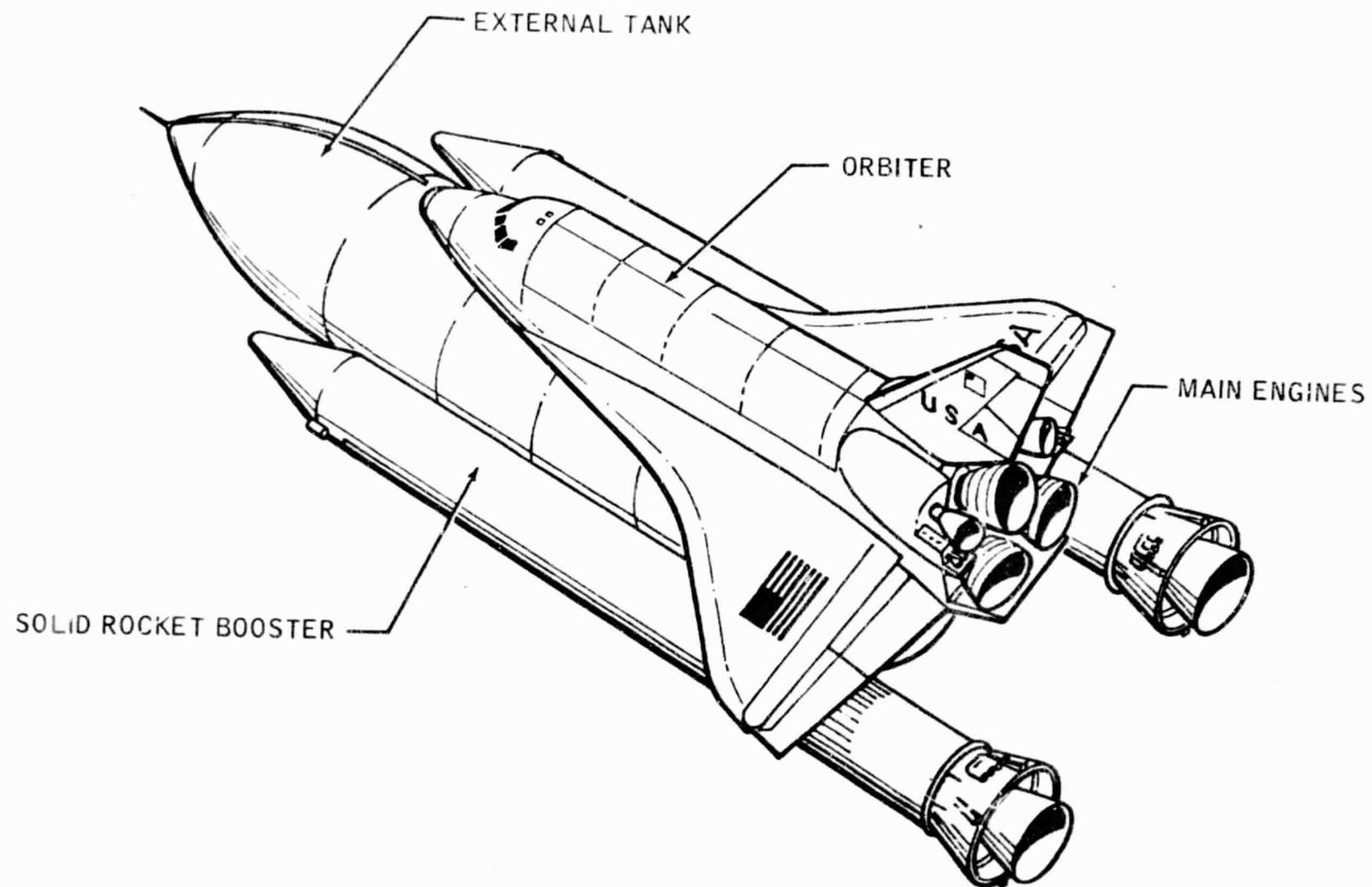
SPACE SHUTTLE PROGRAM FACT SHEET

The primary purpose of the Space Shuttle Program is to provide a vehicle for using space as well as exploring space. The Space Shuttle is designed to reduce substantially the cost of space operations and to provide the ability to support many scientific, commercial and defense activities.

A characteristic of the Space Shuttle is that it will provide a "shirtsleeve" environment so that scientists, engineers and other investigators will be able to travel into space to work personally with their equipment. A cornerstone of the substantial cost reduction afforded by the Space Shuttle is that most of the major elements will be recovered for reuse rather than be expended as was the practice in the past. The Space Shuttle will replace most of the present launch vehicles. Also, the complex payloads of the Space Shuttle can be returned from space or be refurbished in orbit and reused. Thus, the Space Shuttle will provide a vehicle system that will have the capability to launch, repair, service, retrieve and replace many different types of payloads, as well as support manned space activities for up to 30 days.

The Space Shuttle flight system is composed of the Orbiter with its large cargo bay for payloads, the External Tank (ET) containing the propellants to be used by the Orbiter's main engines, and two Solid

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Rocket Boosters (SRBs). The two SRBs are jettisoned after burnout and, by means of a parachute system, are recovered for reuse.

The NASA-Marshall Space Flight Center (MSFC) has the responsibility for design and development of three major elements of the Space Shuttle system: The Space Shuttle Main Engine (SSME) that powers the Orbiter (which uses three SSMEs); the ET which holds the propellants for the SSMEs during launch and ascent almost to orbit; and the SRBs.

The NASA-Johnson Space Center (JSC), Houston, Tex., has been assigned responsibility for the Orbiter and the integration of all the elements into the final vehicle. In this capacity, JSC manages the program and exercises control with respect to technical details, schedules and resources.

The U. S. Air Force is participating in Space Shuttle design and development. It will put the Shuttle into operational use for its particular applications.

The NASA-Kennedy Space Center (KSC), Fla., and Vandenberg Air Force Base, Calif., have been selected as the Space Shuttle launch and landing areas. These two existing facilities offer major advantages with respect to cost, safety, operational requirements and environmental impact. KSC also has the responsibility for developing launch and landing facilities.

THE ORBITER

The Orbiter will be the first space airplane. It is a double-delta-winged vehicle 37.2 meters (122 feet) long with a wing span of 23.8 m. (.78.5 ft.), about the size of a DC-9 jetliner. It will have a

cargo bay that can accommodate payloads up to 4.6 m. (15 ft.) in diameter and 18.3 m. (60 ft.) long, weighing up to 29,484 kilograms (65,000 pounds). Doors on top of the cargo bay will open to permit deployment and recovery of spacecraft. The Orbiter is designed to carry more than 90 per cent of the currently planned and future forecasted satellites into near-Earth orbit.

The Orbiter will carry a crew of three consisting of the pilot, co-pilot and mission specialist. Up to four scientists or payload specialists will accompany the crew, depending upon mission needs. The crew and specialists will travel without space suits and undergo acceleration forces no greater than 3-G during launch and less than 1.5-G during reentry. This is less than the acceleration forces that were experienced in earlier space flights. Because of the near-normal environment, it should be possible to use standard ground laboratory equipment with little, if any, modifications. The use of standard laboratory equipment instead of the specially constructed, highly miniaturized, more expensive components currently used in space flight will result in substantial cost savings. This lower cost will bring space within reach of many new users. Also, since investigators will be able to accompany their experiments into space, malfunctions can be repaired there, resulting in another saving.

The Orbiter is designed to carry its payload into a 185-kilometer (100 nautical miles) orbit and to fly more than 100 missions. It will be launched vertically like a rocket, flown in space like a spacecraft and landed horizontally like a conventional aircraft.

The duration of early Orbiter missions will probably be about

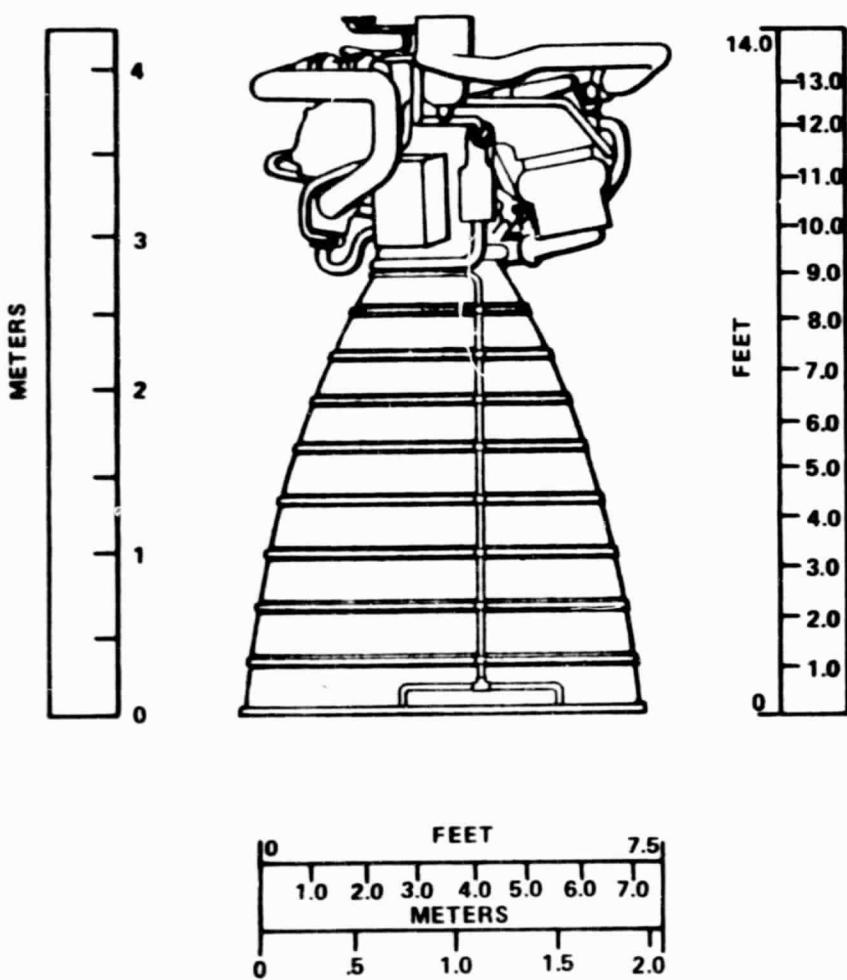
seven days, but by adding supplies of various types it will be possible to extend the mission duration up to 30 days. The Orbiter is designed to have about a two-week turn-around time between missions. Ground turn-around operation for the Space Shuttle system includes post-landing operations, maintenance, refurbishment and pre-launch operations. Pre-launch operations include placing the payload aboard the Orbiter, mating the Orbiter with the External Tank and Solid Rocket Boosters, and performing a launch readiness checkout. The mated configuration is then moved to the launch site.

The prime contractor for the Orbiter is the Space Division of Rockwell International Corp., which is responsible for the design, development, production, test and evaluation of the Orbiter vehicles and support for the initial orbital flights. The prime contractor has also been assigned the task of supporting the Shuttle Program at JSC in integrating all elements of the Space Shuttle system.

SPACE SHUTTLE MAIN ENGINE

The Orbiter will be boosted for about the first eight minutes of flight by the three Space Shuttle Main Engines (SSME) operating simultaneously with the two Solid Rocket Boosters (SRB) during the first two minutes. The SSMEs will continue to burn until the Orbiter is within a few feet per second of orbital velocity, at which time the ET is jettisoned. The final orbit velocity is attained using thrust from the two smaller engines of the Orbital Maneuvering System (OMS). The three high pressure liquid oxygen/liquid hydrogen SSMEs are in the Orbiter aft fuselage in a triangular pattern. The placement of the

SPACE SHUTTLE MAIN ENGINE CHARACTERISTICS



● THRUST		
● SEA LEVEL	375K	(1,868,080 N)
● VACUUM	470K	(2,090,660 N)
● FPL	109%	109%
● CHAMBER PRESSURE		
2970 PSIA	2048 N/cm ²	
● AREA RATIO		
77.5	77.5	
● SPECIFIC IMPULSE (NOM)		
● SEA LEVEL	363.2	$\frac{\text{N sec}}{\text{kg}}$
● VACUUM	455.2	$\frac{\text{N sec}}{\text{kg}}$
● MIXTURE RATIO	6.0	6.0
● LENGTH	167"	424 cm
● DIAMETER		
● POWERHEAD	105" x 95"	267 x 240 cm
● NOZZLE EXIT	94"	239 cm
● LIFE		
7.5 HRS	7.5 HRS	
55 STARTS	55 STARTS	

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engines will allow adequate clearance for thrust vector (steering) control gimbaling.

Each engine is designed to operate at a rated vacuum thrust level of more than two million Newtons (470,000 pounds). The engines use a staged combustion cycle in which all propellants entering the engines are used in the combustion process to produce thrust more efficiently than any rocket engine developed previously. The propellants are raised to high pressure by turbopumps powered by preburners. The exhaust from the preburners is delivered to the thrust chamber rather than vented overboard as was done in the Saturn engines. The total hydrogen/oxygen mixture, burned in the main combustion chamber, flows through the nozzle with an expansion ratio of 77.5:1. This will produce the highest performance possible since combustion will take place under ideal mixing conditions and at high pressure, followed by expansion through the high area ratio nozzle. The nominal chamber pressure is 2,048 Newtons per square centimeter (N/cm^2) or 2,970 pounds per square inch (psi) at 100 per cent thrust.

The SSME system will use four turbopumps. The two low pressure pumps will boost the cryogenics from tank pressure to provide enough additional pressure to eliminate cavitation at the inlets of the high speed, high pressure pumps. The discharge flow from the high pressure pumps (hydrogen 4,275 N/cm^2 or 6,200 psi, oxygen 3,172 N/cm^2 or 4,600 psi) is divided and used for driving the low pressure pumps, before being used in the combustion process. Hydrogen is also used for cooling selected components.

This is the first rocket engine to use an electronic digital

control system known as the "controller." The controller will accept and process vehicle signals and issue commands for start and shutdown. It will regulate the thrust of the engine over a range of 50 to 109 per cent of rated thrust level, depending upon mission needs, to keep the acceleration level below 3-G. The controller will also monitor engine operation and take corrective action automatically in the event of a failure. It receives data from many engine sensors and transmits the data to the vehicle where the information is stored for post-flight analysis. The controller and sensor system will have a built-in redundancy for fail-operational, fail-safe design; i.e., the engine will continue to operate normally after failure of a single component but will shut down safely if a second component fails.

The engine must start in three to four seconds and go from static to high pump speeds within a very short time (29,000 rpm for oxidizer and 35,000 rpm for fuel). The nominal burn time is about eight minutes with a total life span of 7.5 hours.

The engines are being developed by the Rocketdyne Division of Rockwell International Corporation. Rocketdyne will deliver 10 research and development engines and 24 flight engines. Three of the flight engines will be used for the main propulsion test. The first test engine, known as the Integrated Subsystem Test Bed (ISTB), was delivered to the National Space Technology Laboratories in Hancock County, Miss., on March 28, 1975, with the first hot fire test conducted in May, 1975. In addition to other firsts, the SSME is the first reusable rocket engine ever developed.

THE EXTERNAL TANK

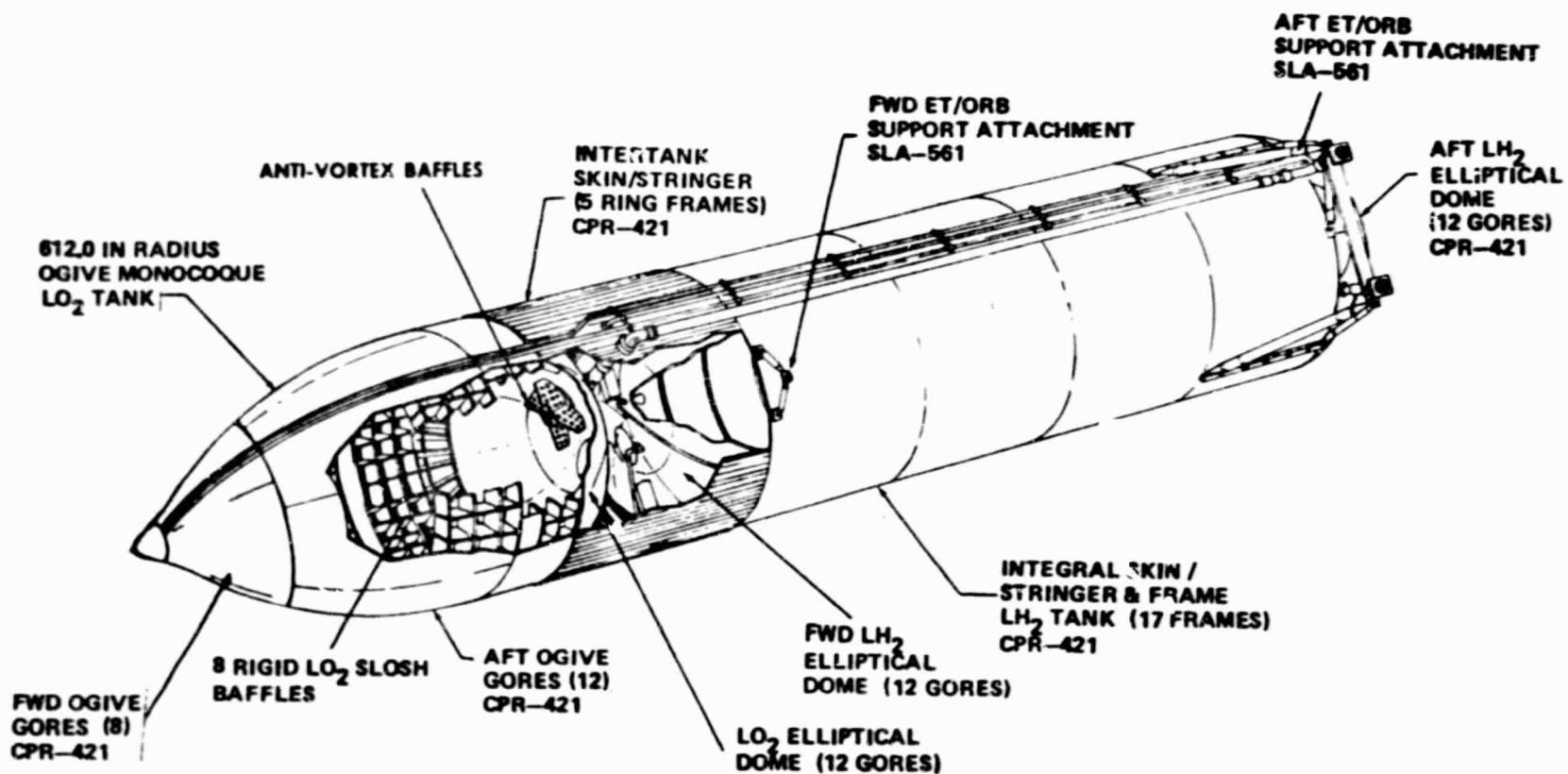
The External Tank is a single assembly 46.8 meters (153.7 feet) long and 8.4 m. (27.6 ft.) in diameter which will weigh 34,020 kilograms (75,000 pounds) without its load of propellants. The ET will have a propellant capacity of 102,514 kg. (226,000 lbs.) of liquid hydrogen and 600,566 kg. (1,324,000 lbs.) of liquid oxygen. The ET supplies propellants to the SSMEs from ground ignition through flight almost to orbit. The ET, with the Orbiter on its back, has an SRB attached to each side. The SRBs will be ejected from the ET at about 46 km. (28 s. mi.) altitude and be recovered from the ocean and refurbished for reuse. After SSME cutoff, the ET will separate from the Orbiter and coast through a ballistic trajectory to impact within a predetermined area.

The ET is being developed by Martin Marietta Aerospace at NASA's Michoud Assembly Facility, New Orleans. This assembly site was chosen because it offers the potential of low-cost operation in a plant used earlier in the Saturn program.

About 70 per cent of the subassemblies will be procured by Martin Marietta in the form of preformed, premachined parts, components and supplies through fixed-price contracts with vendors, resulting in the lowest possible cost from qualified suppliers.

ET/SRB interfaces requiring separation are structural and electrical. ET/Orbiter interfaces requiring separation are structural, fluid and electrical. All fluid controls and valves, except the vent valves, for operation of the engines are in the Orbiter to minimize

SPACE SHUTTLE EXTERNAL TANK



LENGTH	153.68 FT	(47 METERS)
DIAMETER	27.58 FT	(8.4 METERS)
CONTROL WGT	70,000 LBS	(34,000 KILOGRAMS)
PROPELLANT	1.55M LBS	(703,000 KILOGRAMS)

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throw-away costs for each expended ET. Thermal protection will be applied to the ET for protection from aerodynamic and interference heating and from SSME and SRB exhaust heating. Spray-on foam insulation is applied over the forward portion of the oxygen tank, the intertank and the sides of the hydrogen tank to minimize heat loss through the walls.

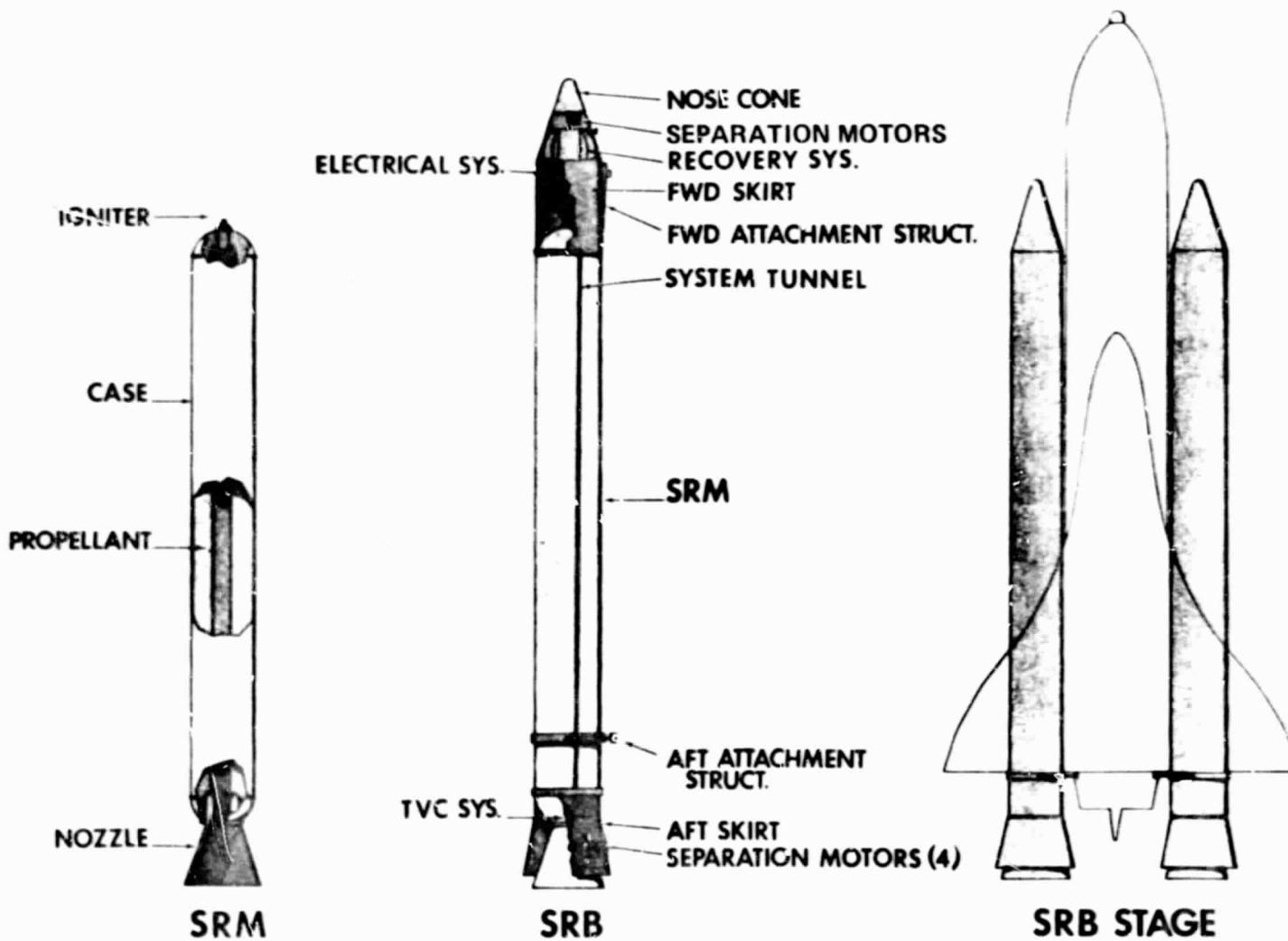
The two main sections of the ogive monocoque structure are the liquid oxygen tank at the forward end and the much larger liquid hydrogen tank aft. The domed tanks are separated by an intertank section. Each tank has slosh and anti-vortex baffles.

The ET has an Orbiter support attachment about one-third of the way aft of the nose cone and dual attachment structures near the aft end. This extends the Orbiter engine area aft of the liquid hydrogen tank section of the ET. Attach points fore and aft for the SRBs are on the right and left sides of the ET.

THE SOLID ROCKET BOOSTER

Each Solid Rocket Booster (SRB) has a solid rocket motor, an aft skirt, thrust vector control, forward skirt and external attach structure, eight separation rocket motors, recovery parachute system in the nose cone, and an electrical power distribution system. Two SRBs are required for each launch. They will fire in parallel with the SSMEs to boost the Space Shuttle from the launch pad up to about 46 km. (28 s.mi.). The SRBs are jettisoned at burnout, parachuted into the ocean, retrieved and towed to land for refurbishment and reuse on later flights. This will be the largest solid propellant booster that has ever flown and

SOLID ROCKET MOTOR/BOOSTER



the only one designed for reuse.

Each SRB is 3.7 m. (12.2 ft.) in diameter and 45.5 m. (149.1 ft.) long. It will carry 498,960 kg. (1,100,000 lbs.) of solid propellants and will provide a thrust at sea level of 11,787,730 N (2.65 million lbs.). Thrust will be reduced into the flight to prevent overstressing the Shuttle vehicle.

The motor cases will be of segmented design. Although the basic motor is well within existing technological and fabrication capabilities, the development of a recoverable and reusable motor casing and nozzle has not been demonstrated. This will require substantial development in materials, fabrication and refurbishment techniques. SRBs of this size have been produced and test fired but not at the rate required nor with the low cost and reusability requirements of the Space Shuttle Program. The first test firing is presently scheduled for July, 1977.

The prime contractor for the Solid Rocket Motor is the Thiokol Corporation of Brigham City, Utah. Various laboratories at the Marshall Center are developing the other subsystems which, with the motor, make up the SRB. These include the electrical assembly, the recovery subsystem (parachutes), thrust vector control system, structures and separation subsystem.

FACILITIES

The requirements of the Space Shuttle elements for which MSFC has responsibility can be met fully through modification and slight additions to those presently available from the Apollo Program. MSFC will perform the structural tests on the ET and SRBs as well as

carry out developmental testing to prove the design concepts of the SSME and ET. The dynamic tests which will simulate the flight conditions that the vehicle will encounter during the boost and launch phases of the mission will also be conducted at MSFC.

The Michoud Assembly Facility at New Orleans is the location for manufacture of the ET.

The National Space Technology Laboratories (NSTL), Bay St. Louis, Miss., is the site for development and production tests of the SSME. In addition, the full Space Shuttle Orbiter propulsion system will be tested at NSTL to prove that the Orbiter aft structure and the three SSMEs it contains, plus the ET, will all operate satisfactorily in combination. The test stands at NSTL have been modified to accommodate this work. Two have already been activated and have been used in tests of the first engine, the Integrated Subsystem Test Bed, and the first development engine. Modifications are still under way on the stand where the Main Propulsion Test Article (MPTA) will be fired.

Development and testing of SSME components and systems are being done at Santa Susana, Calif., where facilities formerly used for acceptance testing of Saturn engines are located. The actual manufacture of SSME is at nearby Canoga Park, Calif.

Fabrication of ground test and development flight motors for the SRBs will be done by Thiokol's Wasatch Division at Lamo Junction, Utah.

TRANSPORTATION

The SSME can be transported by truck, rail, air or water.

Several studies are being conducted which point toward water transportation for the ET. With only slight modifications, presently owned NASA barges are adequate for transporting the ET. However, more barges than now on hand will be required when the Shuttle launch rate increases in the 1980s because the time required for a round-trip between Michoud Assembly Facility and Kennedy Space Center will be about 14 days.

The SRBs will be assembled at the launch site with the SRM being transported by rail and the remainder of the elements by appropriate transportation modes.

MANAGEMENT PLAN

The management plan selected for the Space Shuttle Program makes use of the capabilities and resources developed for previous manned space flight programs. The staff at MSFC, KSC and JSC provides the nation with a strong nucleus of managerial and technical skills. These existing managerial and technical skills, plus the knowledge gained from the Apollo, Skylab and Apollo-Soyuz Test Projects, will contribute to the low cost per flight that makes the Shuttle attractive to NASA and the nation.

BENEFITS

The real cost-savings will be in the cost of transporting cargo the Shuttle can carry to and from space. Each payload pound it carries will cost about \$160 compared with a current price of more than \$900 per pound. Further dollar savings will be realized through reduction of the number of types of launch vehicles needed to support a national space effort, and the cost of the satellites themselves.

The lower cost achieved from the Shuttle should bring space within range of many more users.

The operational Space Shuttle of the 1980s will bring into existence a new era in space operations. It will allow mankind to use Earth resources profitably and wisely, improve worldwide communications and education, develop international understanding and enhance national security, opening up unlimited opportunities in space.

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